Mission Operations Center

GS SDR Section 12

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MOC Manager

Outline

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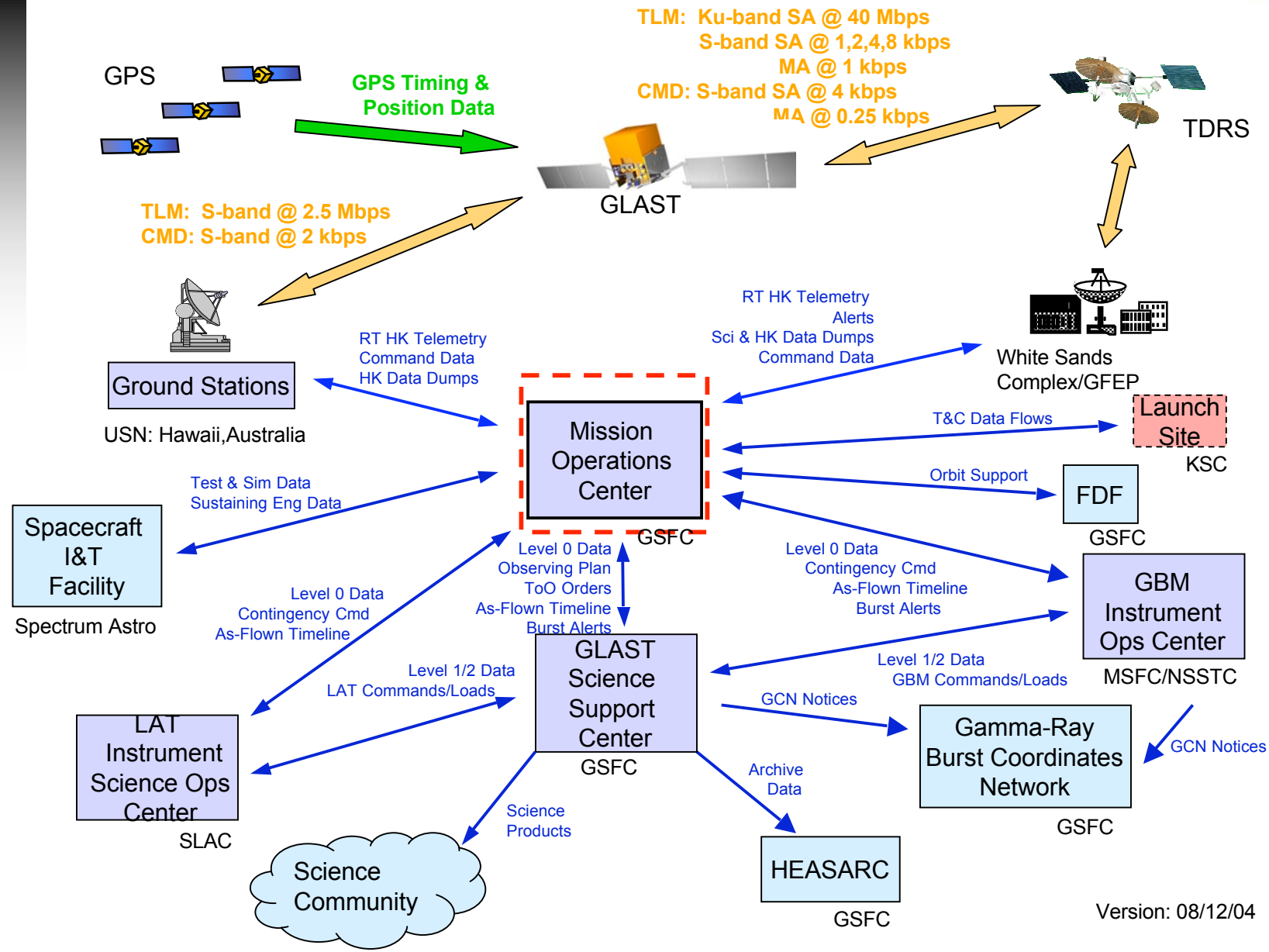
- ***Summary***

Technical Approach

Ground System Architecture



Overview of Functions

- ***MOC/FOT provides "front-line" support for spacecraft and instrument health and safety and performance monitoring/trending***
- ***All commanding done from the MOC telemetry and command system***
- ***Space Network (TDRSS, WSC, DAS, SWSI) – primary communications path for operations***
  - *7-8 scheduled passes per day with TDRSS Ku-band service*
  - *40 Mbps Ku-band science downlink*
- ***Universal Space Network ground station support for backup or contingency commanding and S-band Housekeeping data dumps***
  - *South Point, Hawaii and Dongara, Australia*
  - *2.5 Mbps housekeeping downlink*
- ***LAT and GBM detect Gamma-Ray Bursts and immediately generate Burst Alerts that are sent to the ground via the continuously available SN/TDRSS Demand Access Service (DAS)***
  - *MOC immediately relays GRB alerts to Burst Alert Processor (BAP) for processing and forwarding to GCN for alerting the science community*

Overview of Functions

- ***MOC uses spacecraft provided GPS telemetry to create predictive orbital planning products***
- ***Majority of science and mission operations are pre-planned and executed from stored command loads which are created at the MOC***
- ***Nominal MOC Operations Highly Automated (approach based on Swift, IMAGE, MAP, SMEX, etc. heritage)***
  - *Single 8x5 Staffed Shift post L&EO (On-call FOT outside normal 8x5 shift)*
  - *Manual Activities (FOT)*
    - *Mission Activity Planning and Scheduling, SN and GN (as backup) Scheduling, Real-Time commanding, Telemetry Monitoring, Spacecraft and Instrument FSW Loading, MOC Maintenance (PDB, Software, Hardware)*
  - *Automated Activities (Software, Scripts)*
    - *Off-Shift Pass execution, Data Processing, Telemetry Monitoring, Data Archiving, Trending, Event Logging, Alarm Recognition, Automated Personnel Notification*
- ***Level 0 processing of all data performed at the MOC and forwarded to the GSSC, LISOC, and GIOC***

MOC Requirements

- ***MOC functional and performance requirements document has been developed and reviewed***
- ***MOC Requirements are fully mature and stable***
  - *No major changes recently, only small changes expected from this point*
- ***Baseline version of requirements submitted to Ground System CCB***

Functional Area	*Number of Requirements*
MOC Configuration and Architecture	**123**
Mission Planning and Scheduling	**181**
Telemetry & Command Processing	**214**
Monitoring & Analysis	**219**
Total	**737**

MOC Key Requirements

- ***MOC Configuration and Architecture***
  - *Furnish MOC facility with equipment necessary to control GLAST observatory*
  - *Provide redundancy for all MOC functions and data*
  - *Provide capability to support single 8x5 staffed shift and operate autonomously whenever not staffed*
  - *Provide a reliability of 99.98% for launch critical functions*
  - *Allow maintainability with no loss of performance for life of mission*
  - *Comply with NPG 2810.1 Information Technology (IT) security requirements*

MOC Key Requirements (cont.)

- ***Mission Planning & Scheduling***
  - *Interface with GSSC and IOCs to determine scheduling needs*
  - *Create an Integrated Observatory Timeline*
  - *Schedule SN & USN resources for RF comm*
  - *Generate orbit products for planning tools and for SN/GN acquisition*
  - *Build stored command loads (ATS & RTS loads)*
  - *Re-schedule in response to Autonomous Repoints, as necessary*
  - *Schedule and uplink ToO orders*

MOC Key Requirements (cont.)

- ***Telemetry & Command Processing***
  - *Generate and uplink all commands to the Observatory*
  - *Receive, process and archive Observatory telemetry*
  - *Generate Level 0 telemetry data sets*
  - *Generate telemetry frame quality statistics & log missing frames*
  - *Forward burst telemetry to the BAP and GIOC*
  - *Log autonomous re-points & reschedule missed passes, if necessary*
  - *Automatically page FOT personnel for observatory alarm messages*

MOC Key Requirements (cont.)

- ***Monitoring & Analysis***
  - *Monitor ground system processes, page on-call personnel as appropriate*
  - *Display pages & graphs of real-time and playback HK telemetry*
  - *Provide limit and configuration monitoring of HK telemetry*
  - *Provide event message logging and delogging*
  - *Provide capability to perform trending & analysis of housekeeping data*
  - *Provide web access for remote users to telemetry, trending data & other MOC products*
  - *Support sustaining engineering of observatory & ground system*

Peer Review Summary

- ***MOC Preliminary Design Peer Review held Dec. 15, 2003***
  - *Mission & Ground System Overview, Operations Concept*
  - *Requirements, Preliminary Design, Trade Study plans*
  - *Development & Test Approach, CM/QA*
  - *Flight Operations Overview*
  - *Received 10 RFA's; All 10 RFA's closed, with concurrence of originators*
- ***MOC Detailed Design Peer Review held July 21, 2004***
  - *Operations Concept, Requirements, System Overview*
  - *Detailed Design, Network/Hardware Architecture, Trade Study results*
  - *Development & Test Approach, CM/QA*
  - *Preliminary MOC Facility layout*
  - *Flight Operations Overview*
  - *Received 7 RFA's; all 7 RFA's closed, with concurrence of originators*

MOC Prelim. Design Peer Review RFA's

RFA Number	Title	Orignator	Status
MOC_01	Model attitude for orbit prediction	David Tracewell	CLOSED – sent 1/30, originator concurred. Board Approved
MOC _02	Clarify scheduling timeline, ensure consistency with SN	Steve Tompkins	CLOSED – sent to originat or 1/29; Originator concurred. Board Approved
MOC_03	Clarify where FSW -MOC interface documented	Dan Mandl	CLOSED – sent to originator 1/27 Board Approved
MOC_04	Process to handle contingency procedures	Dan Mandl	CLOSED – sent to originator 1/27 Board Ap proved
MOC_05	Clarify requirements for processing and accessing offline data	Mike Rackley	CLOSED – sent to originator 1/27, originator concurred. Board Approved
MOC_06	Notify SN when AR occurs	Pat Crouse	CLOSED – sent to originator 1/27; originator concurred. Board Approved
MOC_07	Implement TDRSS interface at Spectrum	Steve Coyle	CLOSED – sent to originator 1/27; Originator concurred. Board Approved
MOC_08	Ensure DAS scheduling consistent with planning cycle	Tim Rykowski	CLOSED – sent to originator 1 /27; Originator concurred. Board Approved
MOC_09	Address ITOS compliance with 2810.1	Tim Rykowski	CLOSED – sent to originator, concurred. Board Approved
MOC_10	Define s/c needs for TDRSS ephemeris	Pat Crouse	CLOSED – sent to originator 1/27; originator concurred. Board Approved

MOC Detailed Design Peer Review RFA's

RFA Number	Title	Orignator	Status
MOC_01	Standardize science inputs to the MOC using the ICD to minimize conversion errors	Steve Tompkins	CLOSED, originator concurrence
MOC_02	Scenarios affecting burst alert processing and latency	Mike Rackley	CLOSED, originator concurrence
MOC _03	Establish an on going relationship with GMSEC to ensure future compatibility	Steve Tompkins	CLOSED, originator concurrence
MOC_04	Combine multiple MOC event logs into a master event log to facilitate troubleshooting	Mike Rackley	CLOSED, originator concurrence
MOC_05	Clarify how the MOC and/or software will handle schedule changes from the SN	Tim Rykowski	CLOSED, originator concurrence
MOC_06	Clarify the backup clock correlation functionality of the MOC	Tim Rykowski	CLOSED, originator concurrence
MOC_07	Location of Contingency MOC and detailed rationale to support decision should be provided by GSDR	Tim Rykowski	CLOSED, originator concurrence

Changes since GSRR

- ***Spacecraft RF Design Change: Ku-band TDRSS science downlink replaces X-band GN downlink***
  - *Major design implications, now integrated into baseline*
    - *Front-end required at WSC, new interface to MOC (GFEP)*
    - *Attitude-dependent scheduling required by the MOC to predict TDRSS view periods*
- ***LAT instrument data rate increase by 4X***
  - *Network bandwidth and data storage adjusted, latencies understood*
  - *Solid State Recorder increased to 160Gb*
- ***Backup Ground Station selected: USN in, Wallops & Merritt Island out***
  - *USN's South Point, Hawaii and Dongara, Australia stations*

Accomplishments Since GSRR

- ***Significant Progress on GS & MOC Documentation***
  - *Ground System Requirements Document - review, inputs*
  - *MOC Functional & Performance Requirements Document (Baseline)*
  - *MOC Development Plan (Baseline review version submitted)*
  - *Ops Data Products ICD (working copy in review)*
  - *Procedure/PROC Style Guide (Baseline version submitted)*
  - *DB & Mnemonic Naming Convention Document (Baseline version submitted)*
  - *MOC Design Specification Document (2nd draft completed)*
  - *MOC CM Plan (Baseline review version submitted)*
  - *MOC Test Plan (draft completed)*
- ***Completed trade studies, finalized selection of MOC components***
- ***Defined MOC Network, Hardware and Software Design***
- ***Refined software component designs***
- ***Selected hardware and began setup of Development Lab***

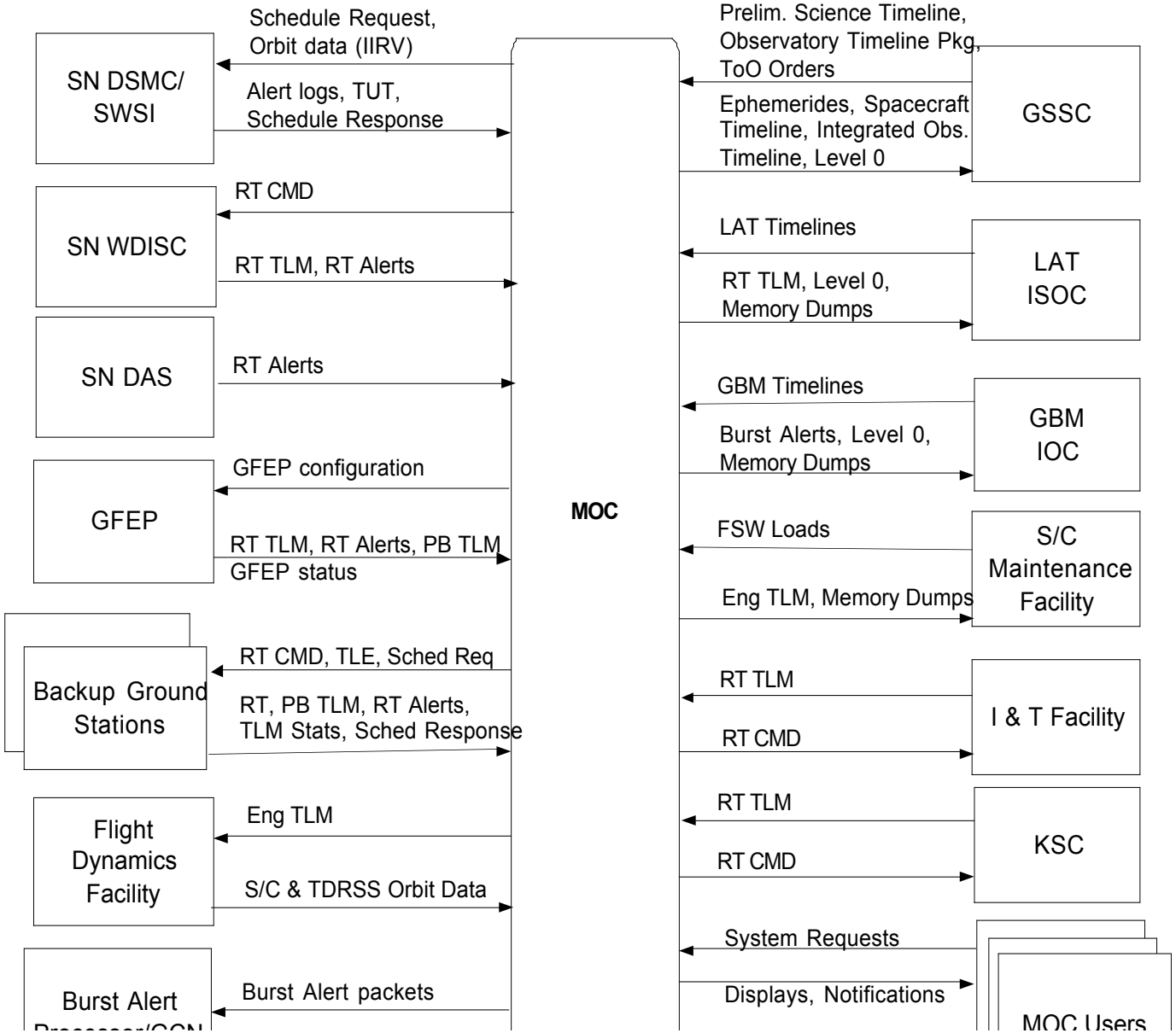
MOC Design

- ***Design Philosophy***
  - *Reliable*
    - *Assess system state through monitoring and logging activity*
    - *Goal: software that will not crash*
  - *Flexible*
    - *Parameters change over mission lifetime (e.g., thresholds, hostnames)*
    - *User configurable vs. coded in software*
  - *Reuse well-tested design and components*
    - *Swift MOC Design & software reuse*
    - *COTS and GOTS software*

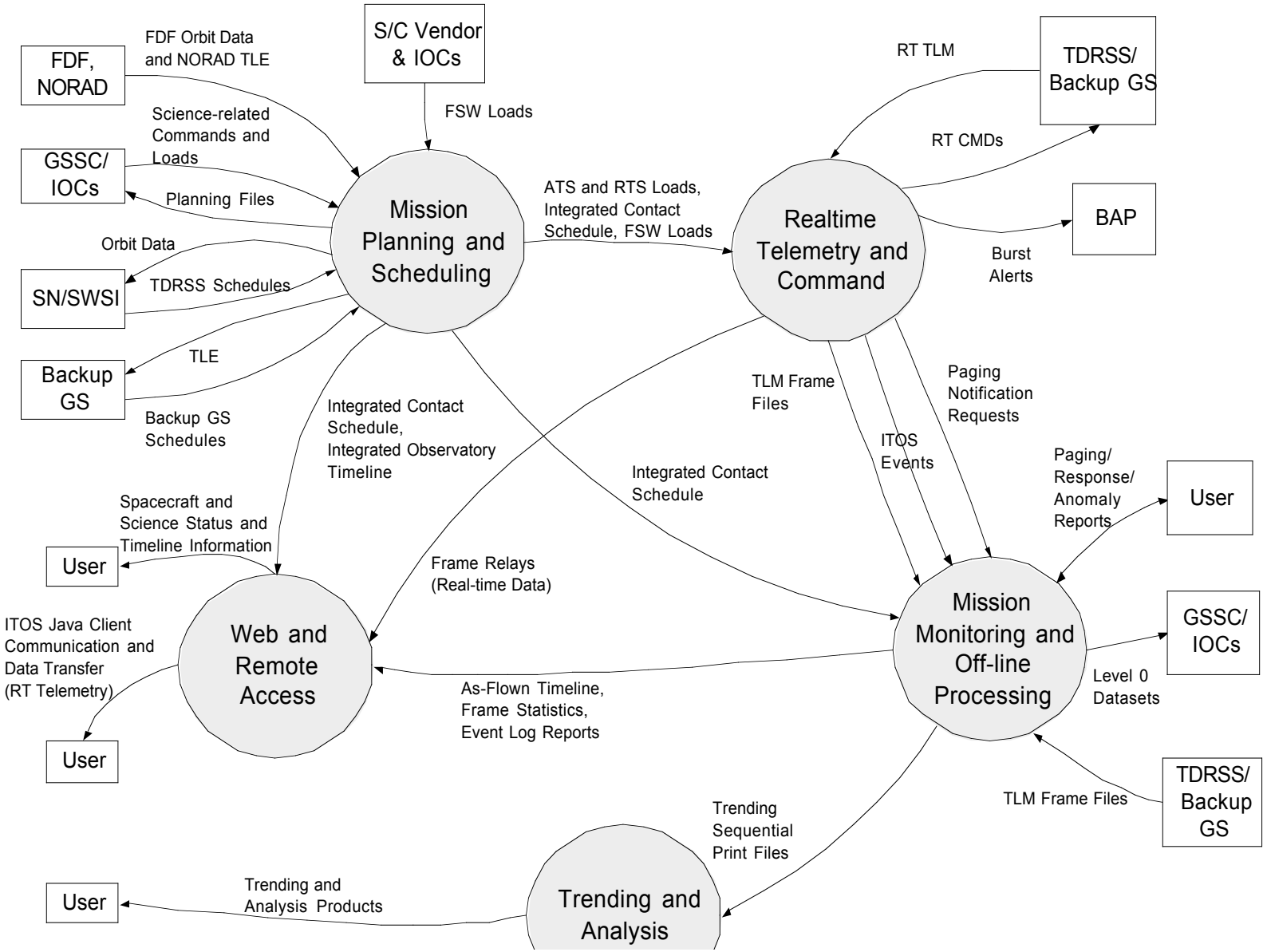
Key Design Drivers

- ***Limited FOV of Ku-band antenna / gimbal assembly***
  - *Makes TDRSS access times dependent on observatory attitude*
  - *Requires modeling of observatory attitude to determine TDRSS access times*
- ***8x5 staffing profile***
  - *Drives the need for an automated MOC*
  - *Requires automated pass plan execution*
    - *Monitor real-time telemetry from observatory*
    - *Alarm Recognition, Configuration Monitoring, Event Logging*
  - *Requires Automated data processing*
    - *Playback SSR telemetry from observatory*
    - *Alarm Recognition, Configuration monitoring*
    - *Event Logging*
    - *Data Archiving*
    - *Level 0 Processing*
    - *Trending*
  - *Requires automated personnel notification*
    - *Alert definition, alert filters, event logs*
    - *Team member profiles, notification lists*

External MOC Interfaces



Software Architecture



MOC Subsystem Descriptions (1 of 4)

- ***Mission Planning and Scheduling***
  - ***Responsible for producing a planned set of spacecraft commands needed to perform science observations and spacecraft housekeeping***
  - ***MPS customized GOTS application (modified from Swift version)***
    - *Integrated Observatory Timeline Generation*
    - *Stored Command Load Generation and Management*
  - ***STK COTS application suite***
    - *Orbit Determination*
    - *Orbital Events Generation*
  - ***Custom applications***
    - *Attitude Dependent SN Contact Scheduling*
    - *Integrated Contact Schedule Generation*
    - *STK Automation Control*
    - *Science Input Processor*
  - ***SWSI GOTS application***
    - *SN Schedule and status web interface*

MOC Subsystem Descriptions (2 of 4)

- ***Real-Time Telemetry and Command Processing***
  - ***Responsible for the receipt, processing, distribution of real-time telemetry and transmitting commands to the spacecraft***
  - ***ITOS GOTS application***
    - *Command Uplink & Verification*
    - *Telemetry Downlink, Processing, Display & Distribution*
    - *Limit Checking & Configuration Monitoring*
    - *System Event Generation*
  - ***Custom applications***
    - *DAS Automation Monitoring and Control (AMAC)*
      - *Receives Alerts via DAS, forwards Burst Alerts to BAP & GIOC*
      - *Generates pages requests to FASAT for Observatory 911 Alerts*
    - *Real-time TDRSS AMAC*
      - *Automated Pass Execution*

MOC Subsystem Descriptions (3 of 4)

- ***Mission Monitoring and Off-Line Processing***
  - ***Responsible for the processing of playback telemetry, collecting and logging telemetry statistics and the archiving of MOC files.***
  - ***FASAT COTS application***
    - *Monitor Events for Anomalous Conditions*
    - *Automatic Notification to On-call Personnel for Emergencies*
  - ***ITOS GOTS application***
    - *TLM Processing, Level 0 Processing, & Archive*
  - ***Custom applications***
    - *Generate As-flown Timeline (Timeline Monitor)*
    - *Data Accountability & Quality Statistics (Frame Accounting)*
    - *Offline Automation Monitoring and Control (AMAC)*
      - *Runs ITOS to process recorded TLM files, generate L0 files*
      - *Distributes L0 files to GSSC/IOCs using FastCopy application*
      - *Runs Timeline Monitor and Frame Accounting*
      - *Loads DTAS trending system*

MOC Subsystem Descriptions (4 of 4)

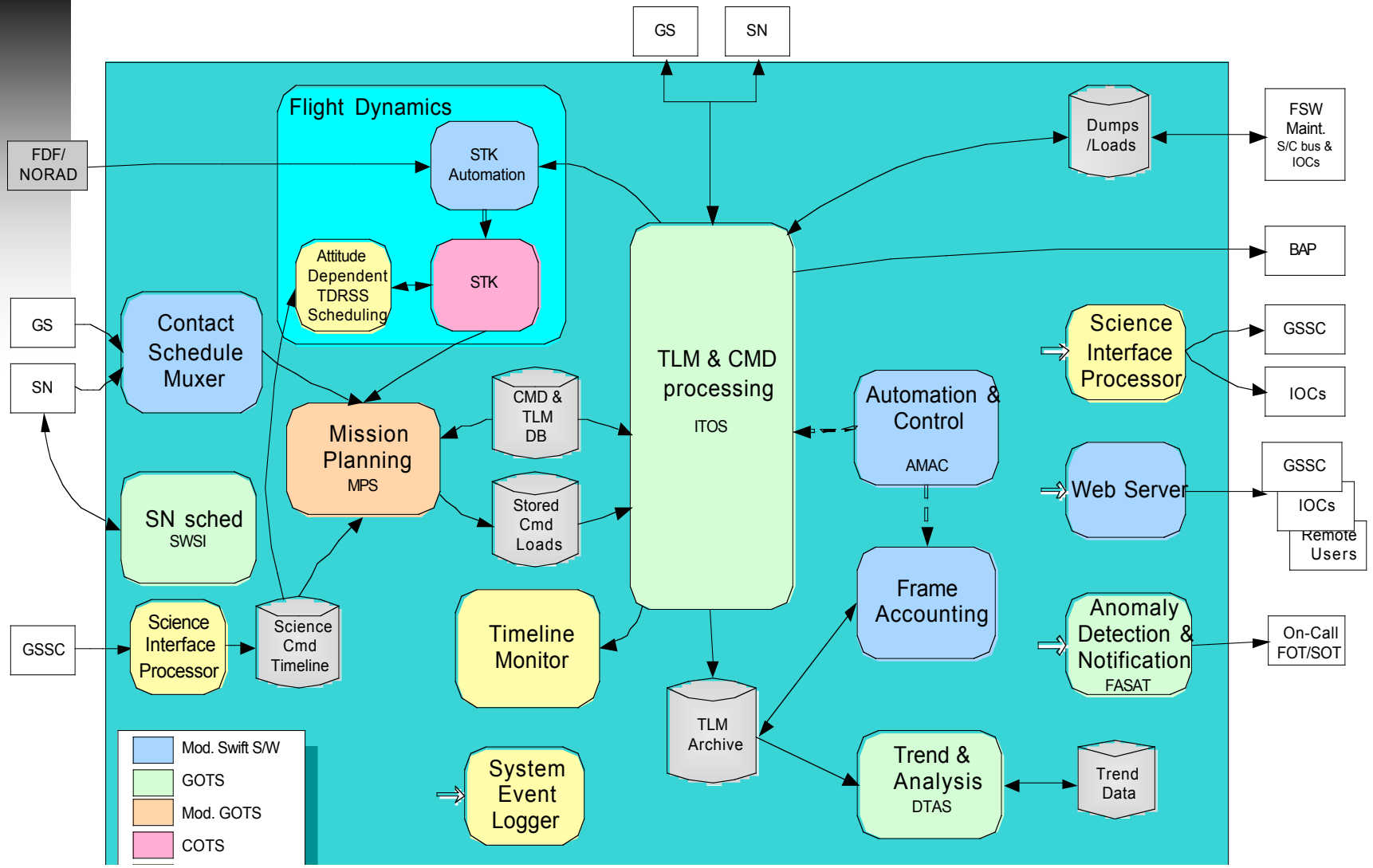
- ***Trending & Analysis***
  - ***Responsible for the trending and analysis of downlinked telemetry data for the evaluation of spacecraft and instrument health and safety.***
  - ***DTAS GOTS application***
    - *Generate trend data, accumulated over life of mission*
    - *Generate plots, reports, statistics on selected telemetry data*
- ***Web and Remote Access***
  - ***Responsible for providing the primary point of access for outgoing data and information from the MOC to authorized external users.***
    - *Remote ITOS displays*
    - *Remote Trending (DTAS) access*
    - *Anomaly Reports*
    - *MOC Web Site*
  - ***Apache Web Server***
  - ***ITOS GOTS application***
  - ***Custom applications***

ITOS Modifications to Support GLAST

- ***GLAST unique capabilities have been identified, captured, and conveyed to the ITOS developers***

#	Requirement T itle	Requirement Comments & Clarification
1	GBM Instrument time data format	The GBM time format is not a CCSDS standard. GBM time format is 4 octets, (units are 0.1 second). The fine time is 2 octets, (units are 2 microseconds). S/C time is elapsed time since midnight, January 1, 200 1 epoch.
2	LAT Instrument time data format	LAT requires time types with 4 bytes of fine time
3	Level 0 duplicate removal and time ordering	The individual level 0 files should be free of duplicate packets, time ordered, and annotated for quality.
4	Science packet sync marker	The science packets are stored w ith a sync marker and ITOS will need to look for this to properly extract the data.
5	Make Load Script	Scripts that converts binary memory loads into the ITOS load format
6	EPOCH TIME rollover	GBM EPOCH TIME only last 12 years and will rollover during the mission. ITOS should compensate for the rollover of GBM time to facilitate level 0 processing, archive entry and retrieval, and sequential print file generation
7	GBM housekeeping packets data validity (data directed unpacking)	GBM generates housekeeping packets where some data is not always valid. Such packets included parameters wh ich indicate when these fields are and are not valid. To handle this gracefully, ITOS should be required to implement data directed unpacking. This will allow the system to select how or if it will unpack regions within packets based on data values within the packet.
8	ITOS handling of the SIIS CLCW	ITOS did not cleanly handle the CLCW produced by the SIIS which, as stated below, cycles among several virtual channels. This is a bug which should be fixed.
9	Command load sequence flags	The LAT team is usin g the CCSDS sequence field during uploads. I TOS will need to implement its use to upload the LAT files.

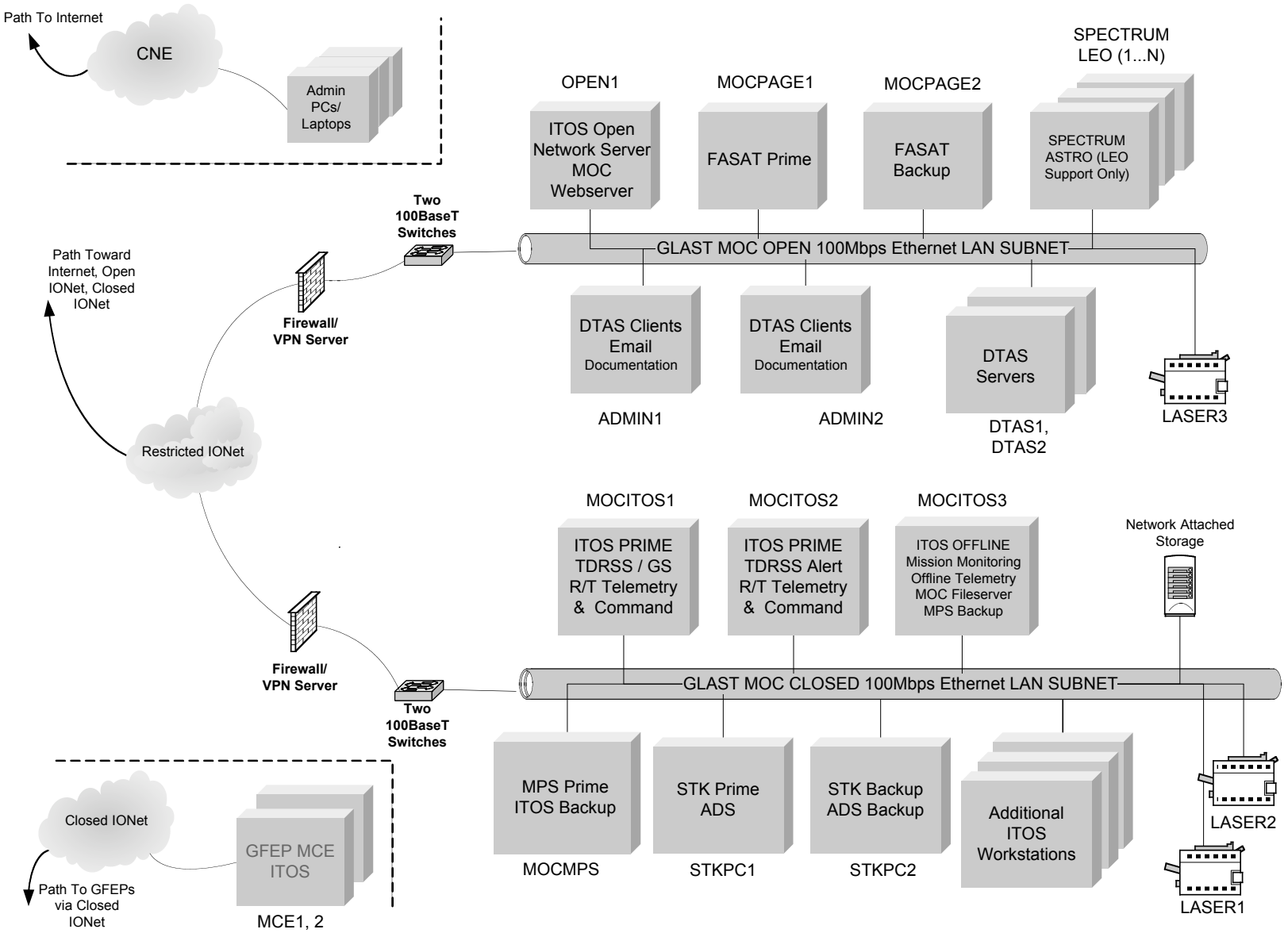
MOC Software Components



MOC Software Components Summary

SUBSYSTEM	SOFTWARE	SOURCE	HERITAGE
Utilities	Syslog-ng	Freeware	
	Event & Archive Viewer		New
	Java Event Server	HST CCS	HST
	FASTCopy	SoftLink	WFF(SAFS), MSFC
Mission Planning and Scheduling	MPS – Mission Planning System	GSFC	TRACE, WIRE, Swift
	STK – Satellite Tool Kit	AGI	GSFC, NORAD
	SWSI Client	GSFC	Swift
	Contact Schedule Muxer	GSFC	Swift (w/ mod)
	STK Automation	GSFC	Swift (w/ mod)
	TDRSS Scheduling (attitude-dependent)		New
	Science Interface Processor		New
Real-Time Telemetry and Command	ITOS- Integrated Test and Operations System	GSFC	SMEX, Swift
	Event Delogger	GSFC	Swift
	AMAC (DAS, Real-time)	GSFC	Swift (w/ mod)
Mission Monitoring and Off-line Processing	ITOS - Integrated Test and Operations System	GSFC	SMEX, Swift
	FASAT -Fast Access Situational Awareness Toolkit	GSFC	USAF
	Timeline Monitor		New
	Frame Accounting	GSFC	Swift
Trending and Analysis	DTAS – Data Trending and Analysis System	GSFC	SMEX, Swift
Web and Remote Access	ITOS- Integrated Test and Operations System	GSFC	SMEX, Swift
	Apache – Web Server	Open-source	
	MOC Product Web Page and access scripts		New

MOC Network



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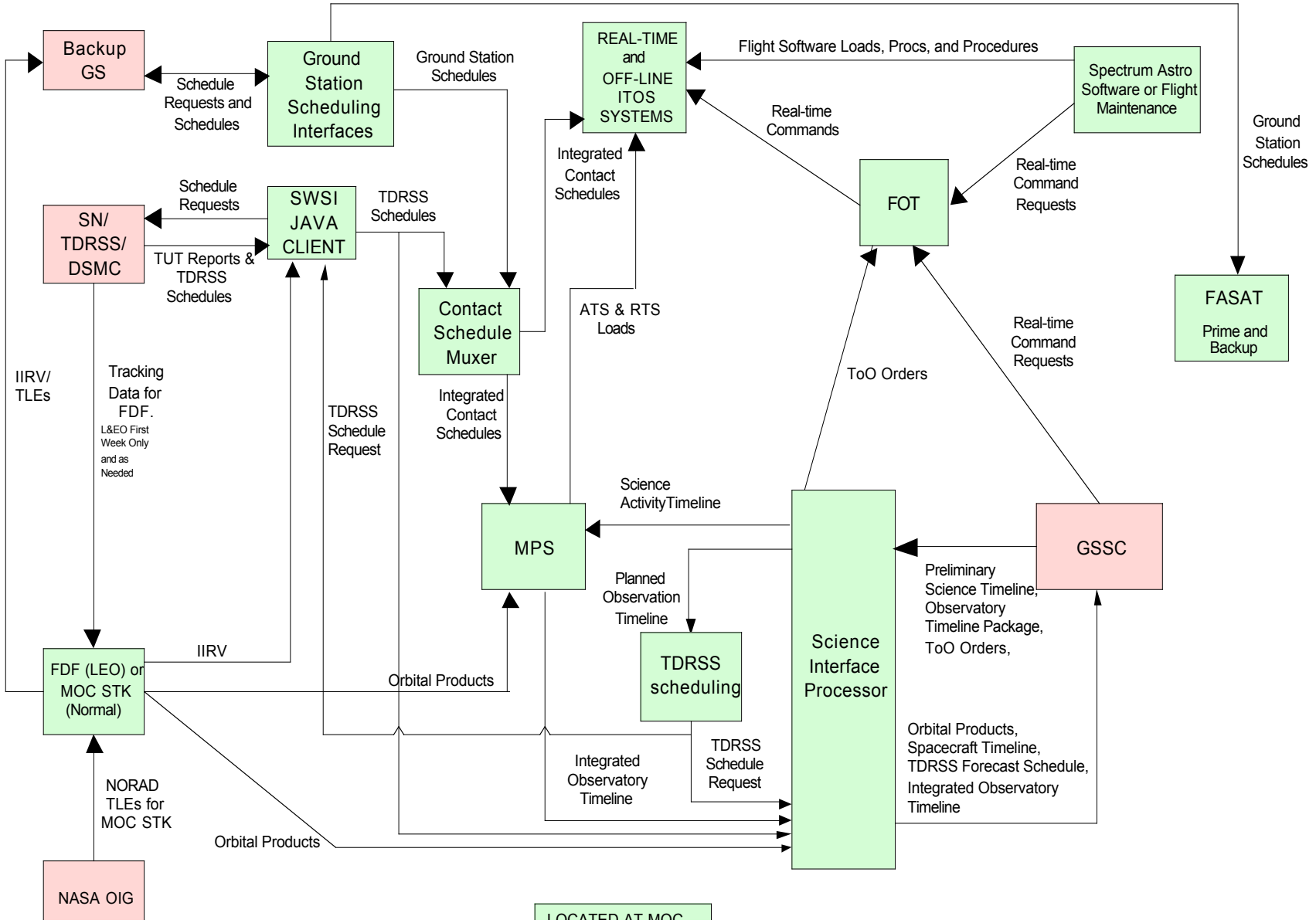
Hardware and Network Architecture

- ***Security***
  - *Specific GLAST MOC Security Plan*
  - *Will follow accepted NASA procedures as defined in NASA Procedural Requirements (NPR) 2810.1*
  - *Will follow Internet Protocol Operational Network Access Protection Policy and Requirements 290-004 document required for all IONet users.*
  - *Strict access control*
    - *Firewalls with deny-based filtering, VPN, user accounts*
  - *Isolated subnets for real-time and remote access functions*
  - *Regular vulnerability scanning*
  - *MOC personnel work directly with GSFC security personnel & GLAST Ground System Engineer*
- ***Redundancy***
  - *Linux workstation based tasks such as ITOS real-time and off-line operations and Mission Planning performed interchangeably on any of the MOC Linux workstations.*
  - *Paging, DTAS, and Flight Dynamics utilize fully redundant Prime/Backup Microsoft Windows workstations*
  - *Copies of Operations products and data stored off-site*

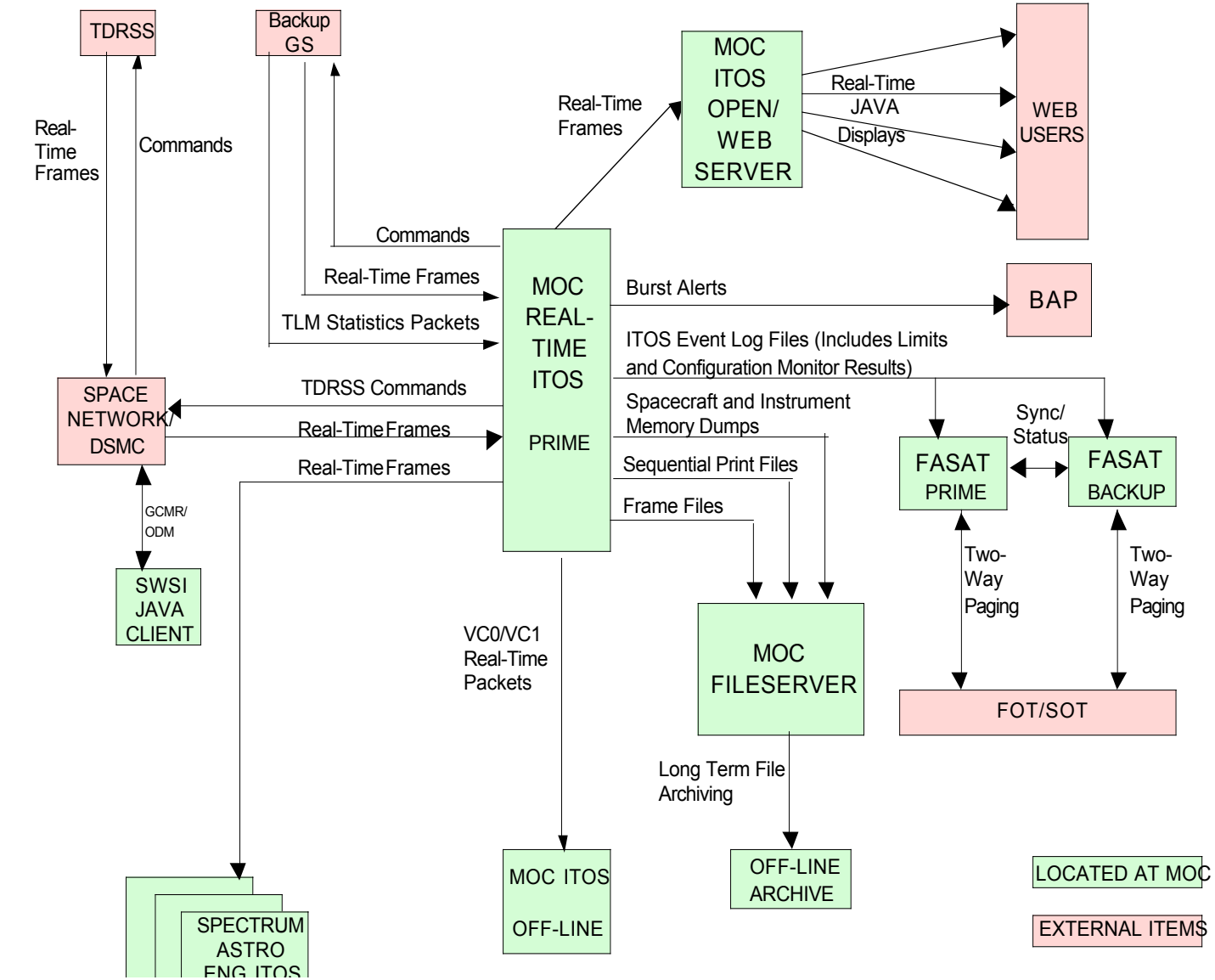
MOC Hardware

Hardware	Platform	Operating System	Comments
ITOS workstations	Intel	Red Hat Linux	Dual monitor, dual cpu
MPS workstations	Intel	Red Hat Linux	Also serve as b/u ITOS ws
Open server	Intel	Red Hat Linux	
FASAT servers	Intel	Microsoft Windows	
DTAS servers	Intel	Microsoft Windows	
STK workstations	Intel	Microsoft Windows	
General Purpose PCs	Intel	Microsoft Windows	
Firewall/VPN Server	Intel	Microsoft Windows	Checkpoint
Network Attached Storage	[n/a]	[n/a]	RAID level 5
Switches	[n/a]	[n/a]	Netgear Gigabit switches

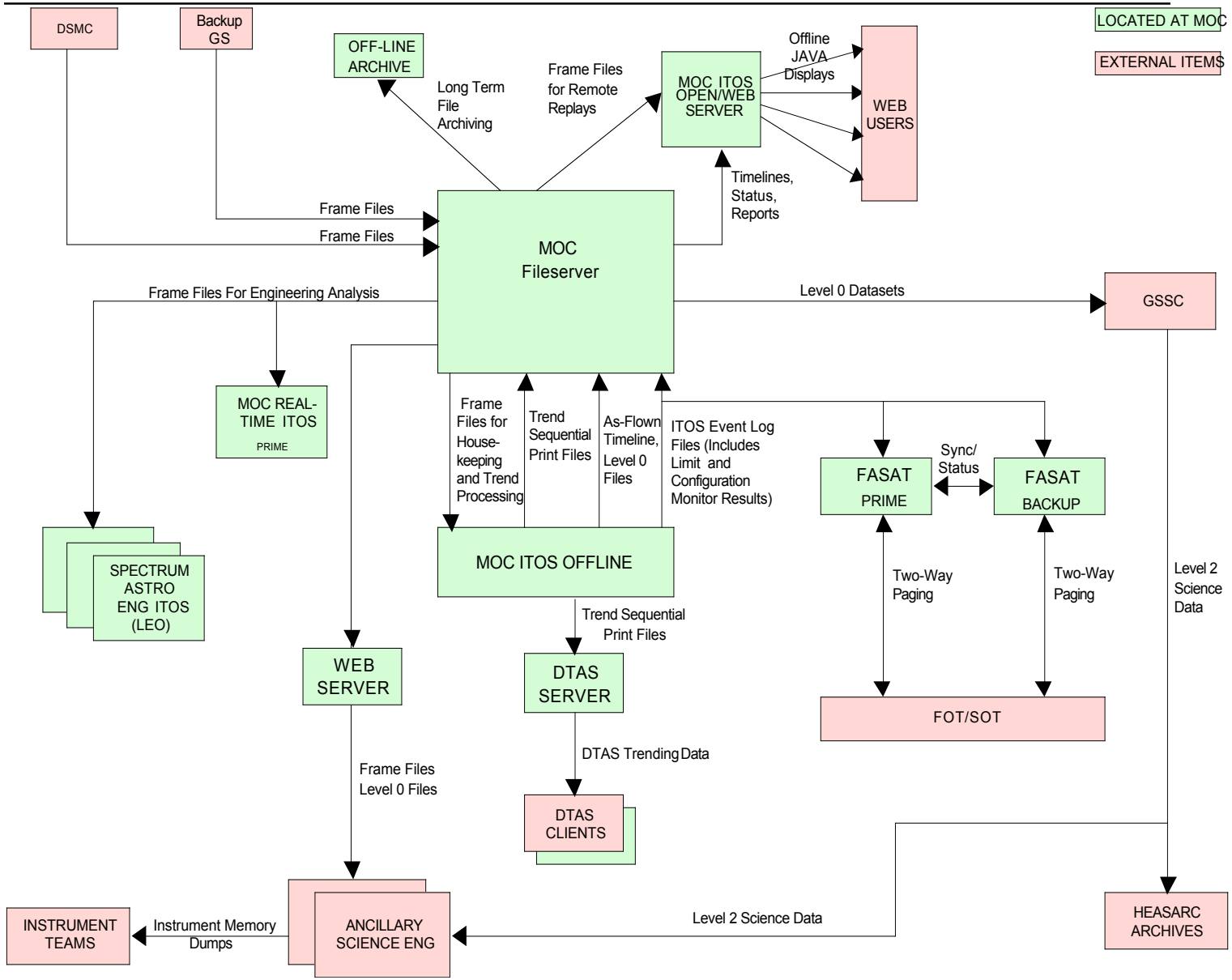
Mission Planning Data Flow



Real-Time Command, Telemetry and Product Data Flow



Off-Line Telemetry Data Flow



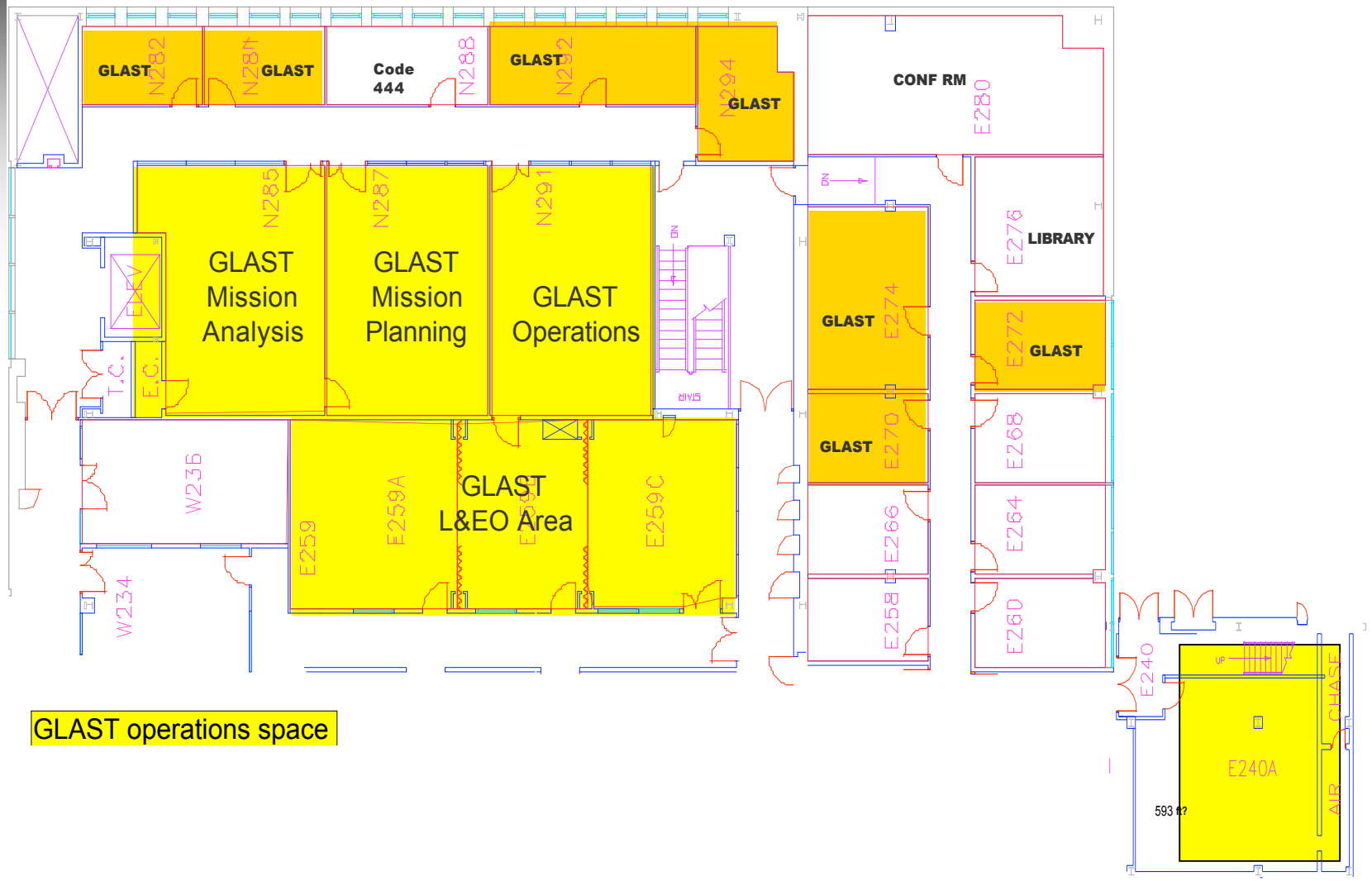
MOC Facility

- ***Accommodates all equipment and teams during L&EO and normal operations***
  - *GSFC; building 14 - rooms N285, N287, and N291*
  - *E259A through E259C and E240A available during L&EO*
  - *Office/support space in surrounding areas*
  - *Provides for Project, Spectrum, LAT, and GBM engineers*
- ***Physical security provided by GSFC***
  - *Keycard access required for building 14, secondary keycard access required for the MOC areas*
- ***Status***
  - *N287 and N291 have been emptied and are being readied for MOC occupation*
  - *Plans in place to ready the remaining areas well prior to mission need dates*

GLAST MOC Areas

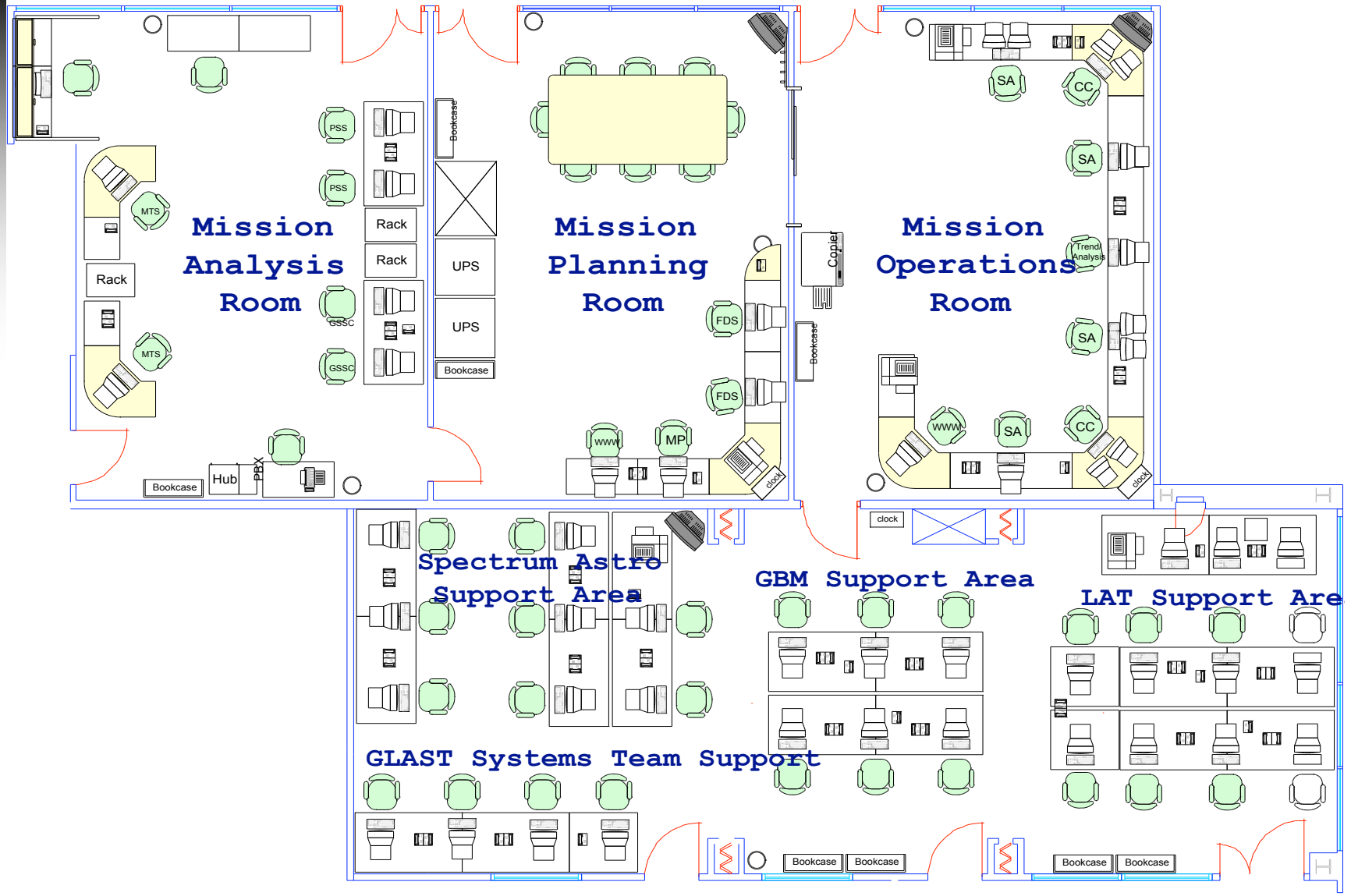
Building 14

Second Floor North Corridor



GLAST operations space

Preliminary MOC and L&EO Area Layout

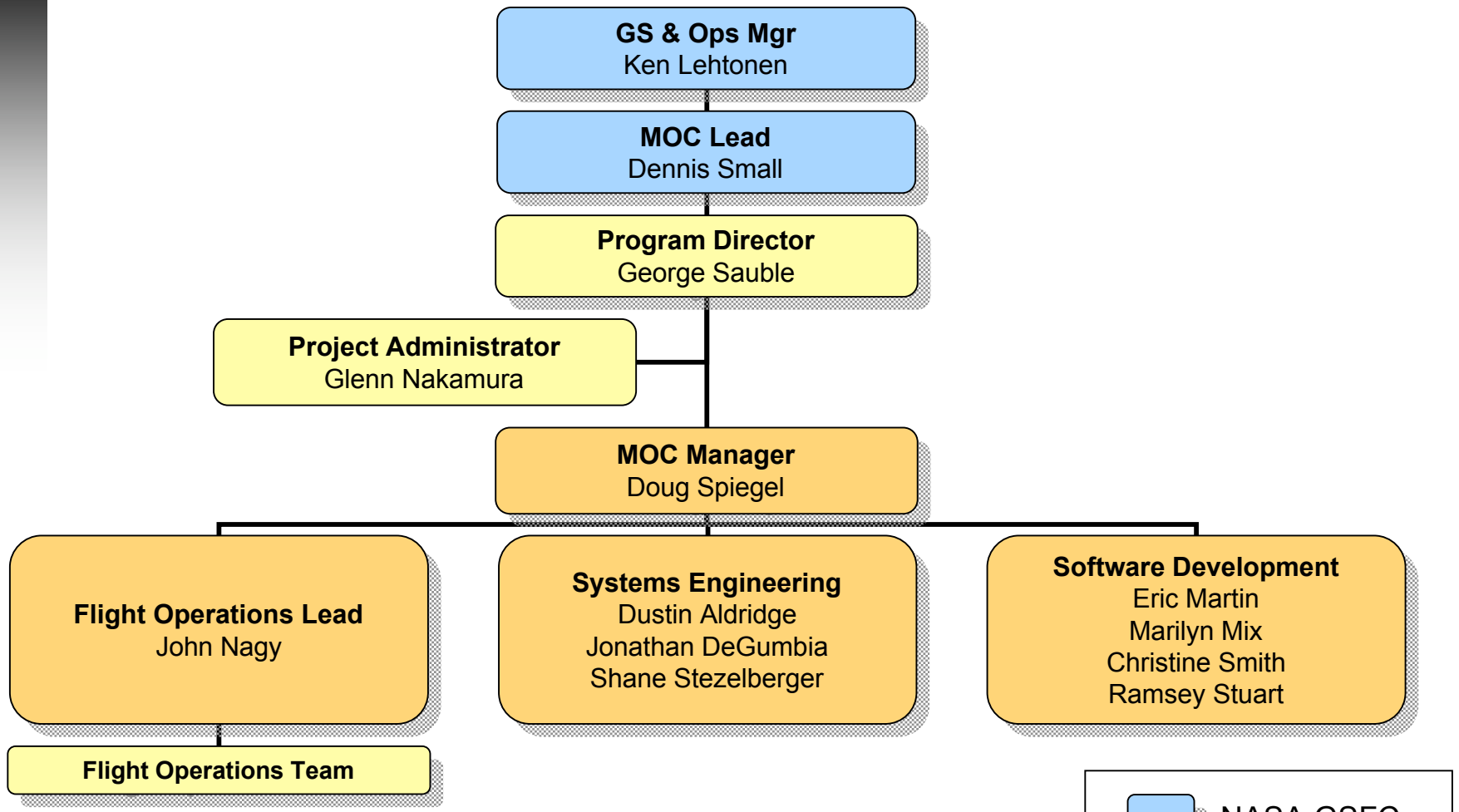


Voice Communications

- ***Voice communications***
  - *Government provided voice equipment and lines in MOC*
  - *Provides communication with Space Network, Flight Dynamics, KSC, Mission Operations loops*
  - *USN can be connected into the MOC by GSFC Voice Control*
  - *Current system is the Voice Switching System (VSS) and Voice Distribution System (VDS)*
  - *Mission Operations Voice Enhancement (MOVE)*
    - Replacing the VSS and VDS currently in use
    - Same complement of voice loops provided by the existing system
    - Nascom responsible for troubleshooting
    - System scheduled for delivery to GSFC in Sept 2006

Management Approach

MOC Team Organization



MOC Development Approach

- ☑ ***Base design on Swift MOC model, leverage Swift system reuse and staff experience***
- ☑ ***Define MOC Development Plan***
- ☑ ***Develop Operations Concept, detailed MOC Requirements (level 4)***
  - *Flow down from GSRD, establish traceability*
- ☑ ***Define architecture, interface protocols, develop system design***
  - *Perform trade studies as needed to assess best fit of functionality, cost, ease of use, ease of maintenance*
- ☐ ***Develop software***
  - *Integrate COTS/GOTS packages, configure & tailor where necessary for GLAST needs*
  - *Augment with custom s/w to meet GLAST specific requirements*
- ☐ ***Build and test using an incremental approach***
  - *Phase build functionality with needs of ground system test program*

Project Management

- ***Maintain detailed MOC development schedule***
  - *Includes tasks for*
    - *System engineering*
    - *Software development & Testing*
    - *Ops preparation*
- ***Report Development Progress***
  - *Provide routine status reports to GS/Ops Manager & MOC Lead, identify issues/concerns and any risk items*
  - *Track monthly cost/schedule against plan, report variances*
- ***Participate in routine meetings***
  - *Working groups – GOWG, GSSC-MOC Working Group*
  - *Staff meetings – GS Staff, Goldbelt Orca/Omitron Staff*
  - *Design meetings – Technical Interchange Meetings (TIMs), PSS, GFEP*
  - *Ground system CCB meetings*
- ***Manage Risk***
  - *Identify and track risks*
  - *Elevate risks to Ground System Risk Management (as necessary)*

Project Management (cont'd)

- ***Participate in series of internal and external Reviews***
  - *Informal Walkthroughs*
    - *MOC requirements*
    - *Component designs*
    - *Code & unit tests*
    - *System test cases*
  - *Peer Reviews*
    - *MOC Preliminary Design*
    - *MOC Detailed Design*
    - *Flight Operations*
  - *Release Delivery Reviews (Build 1-4)*
  - *Formal Reviews*
    - *Ground System Requirements Review*
    - *Ground System Design Review*
    - *Mission Operations Review*
    - *Operations Readiness Review*

Configuration Management

- ***Ground System CM***
  - *Key MOC Products controlled by the Ground System CCB*
- ***MOC Internal CM***
  - *Documented in MOC CM Plan*
    - *All changes to controlled products reviewed*
    - *Any requirements/scope or interface changes elevated to GS CCB for approval*
  - *Offers change control and version tracking for*
    - *MOC internal documentation*
    - *MOC operations products*
    - *MOC software including configuration files and data files*
  - *Uses*
    - *TrackGear for MOCR management*
    - *Docushare as document repository*
    - *CVS as ops product and software repository*
  - *Provides the ability to reproduce the software environment at any past moment in time*

Discrepancy Management

- ***DRs written on discrepancies encountered throughout test program***
- ***DR Tracking is maintained through a coordination of ground system and element level systems***
- ***Ground System Level***
  - *DR Review Board chaired by Ground System Engineer*
  - *Uses project provided on-line system for DR management*
  - *Closes out DRs to element level where applicable*
- ***MOC Internal***
  - *Uses TrackGear for DR management*
  - *DRs generated internally or handed down from ground system level*
  - *All DRs maintained and tracked to closure*
  - *Online access allows the Project complete insight to DRs*
  - *DR status, resolution plans coordinated with NASA MOC Lead*

MOC Requirements Tracking & Verification

- ***Requirements Verification Matrix has been created from the MOC level 4 requirements***
- ***For each requirement in the table, a separate column will track***
  - *Allocations to software components*
  - *Allocations to software builds*
  - *Validation method - Analysis, Inspection, Test, or Demonstration*
  - *Associated test case*
  - *Associated procedure*
- ***Matrix is maintained in parallel to the MOC requirements document***
- ***Matrix serves as primary tool for tracking the verification & validation status of each requirement as tested at the element level***

MOC Test Approach

- ***MOC test approach structured to verify the MOC's ability to perform mission***
  - *Operations scenario-based testing*
  - *Validation of level 4 requirements*
- ***Complete test approach detailed in MOC Test Plan***
  - *Hierarchical build & test approach*
    - *Unit level testing – Informal white box testing of individual or small number of integrated modules.*
    - *Integrated build testing – Black box, function-based testing of a group of integrated modules.*
    - *Interface testing – Function-based testing of MOC external interfaces*
    - *MOC system testing – Function and performance testing used to validate level 4 requirements*
  - *Testing relies on use of stubs, drivers, simulators (PSS, MTS, Hotbench), and test data as necessary*
  - *MOC internal DRs used to identify and track bugs*
  - *Regression testing performed to verify changes have not adversely affected existing functionality/performance*
  - *Internal test results presented during Release Delivery Reviews*

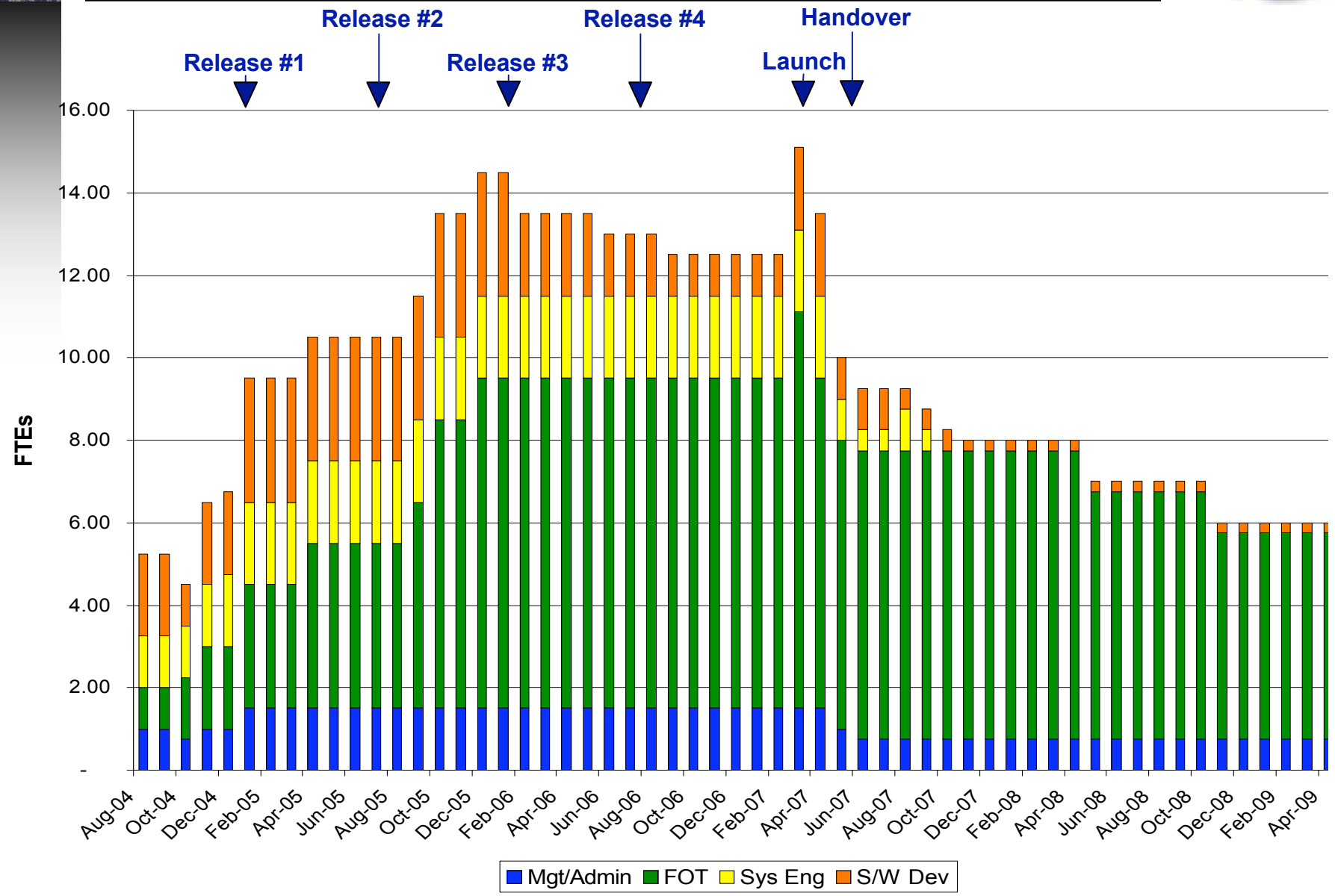
MOC Build Plan

- ***Release 1 (Jan., 2005) – GRT#1, 2***
  - *TLM & CMD Processing*
  - *Level 0 TLM Processing*
  - *Integrated Timeline and Command Load Generation*
  - *Level 0 Product Distribution*
  - *Contact Scheduling (S-band)*
- ***Release 2 (July, 2005) – GRT#3, 4***
  - *GSSC Interface*
  - *Alert Handling*
  - *Timeline Monitoring*
  - *Flight Dynamics*
- ***Release 3 (Jan., 2006) – GRT# 5, 6 (All Launch critical functionality)***
  - *Attitude-dependent Contact Scheduling*
  - *System Automation*
  - *System Monitoring & Paging*
  - *Trending & Analysis*
- ***Release 4 (July, 2006) – GRT #7 (Launch Ready/Clean up Release)***

MOC Documents

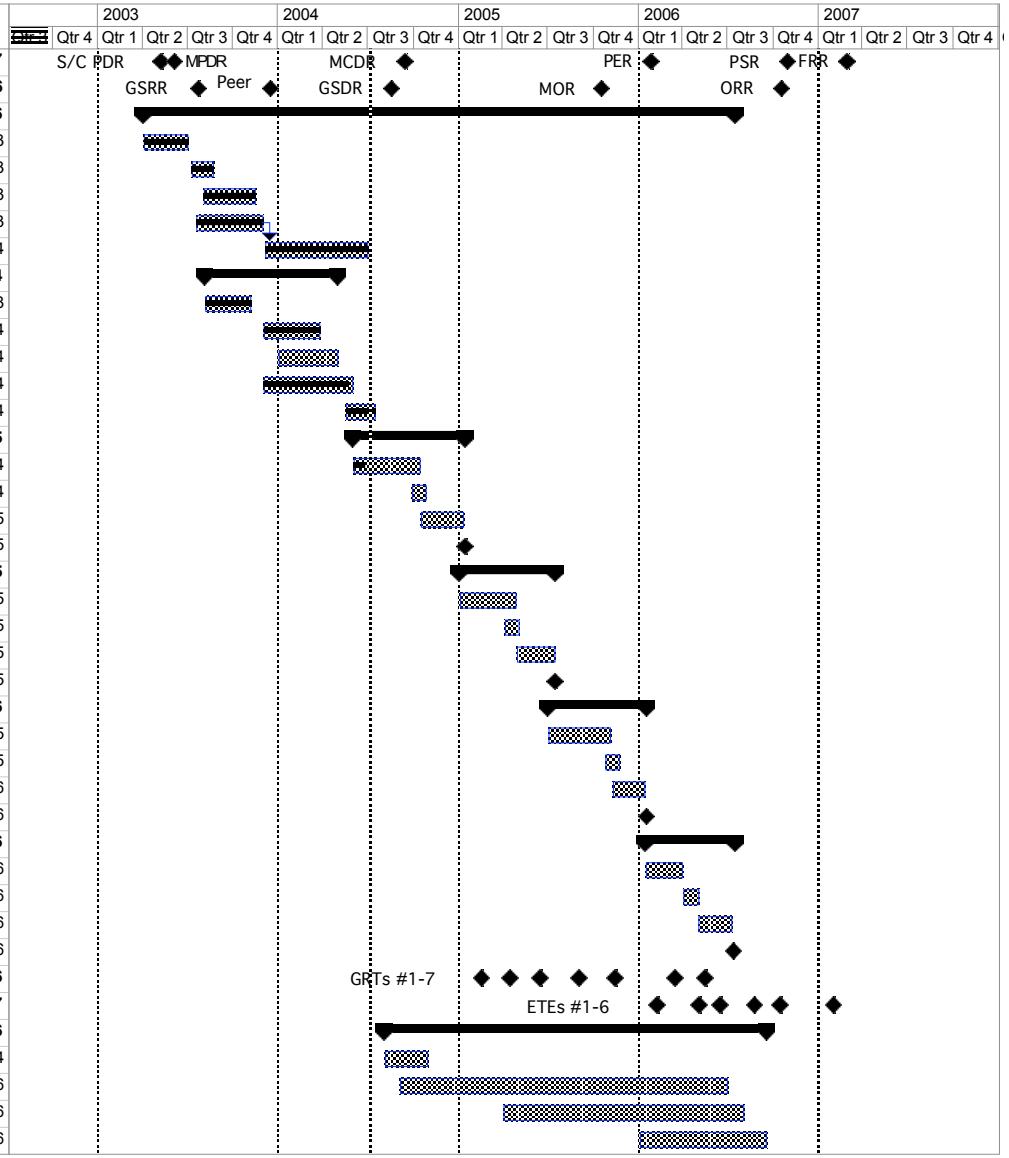
Document	Preliminary		Baseline		CCB	Doc No.	Author	Comments
	Milestone	Date	Milestone	Date				
Operations Concept Document	-	-	SRR+1 mo.	8/22/03	Project	433-OPS-001	J. Nagy	Rev A (Original baselined Mar'02
Development Plan	SRR+1 mo.	8/22/03	GSDR	8/11/04	Internal	492-MOC-001	D. Spiegel	V1.0 delivered 10/30/03; Rev. 1.1 8/11/04
MOC Functional & Performance Requirements	GSDR -6 mos.	11/15/03	GSDR-2 mos.	6/30/04	GS	492-MOC-002	J. DeGumbia	V1.01 7/26/04ready to be baselined
DB Format & Naming Convention	SRR+1 mo.	8/22/03	GSDR	7/9/04	GS	492-MOC-003	J. Nagy	V1.0 ready to be baselined
Procedure & PROC Style Guide	GSDR -5 mos.	12/1/03	GSDR	7/16/04	GS	492-MOC-004	J. DeGumbia	V1.0 ready to be baselined
Design Spec	GSDR -6 mos.	11/30/03	GSDR+3 mos.	9/30/04	Internal	492-MOC-005	M. Mix	Rev prior to DD Peer Review completed 7/8/04
CM Plan	GSDR -4 mos.	1/30/04	GSDR	8/15/04	Internal	492-MOC-006	M. Mix	V0.02 distributed for review 6/30/04
MOC Test Plan	GSDR-1 mo.	7/15/04	GSDR+2 mos.	10/31/04	Internal	492-MOC-007	J. Nagy	V0.02 incorporated review comments
Security Plan	GSDR	8/15/04	GSDR+2 mos.	10/15/04	GS	492-MOC-008	D. Aldridge	V0.01 distributed for review
Ops Data Products ICD (MOC to GSSC/IOCs)	GSDR -6 mos.	11/5/03	GSDR+2 mos.	10/15/04	GS	492-MOC-009	J. Nagy	V1.0 distributed for review 7/30/04
MOC-Backup GS ICD	GSDR	8/15/04	GSDR+2 mos.	10/15/04	GS	492-MOC-010	J. DeGumbia	80%; On Hold, dependency on USN contract (NENS)
Mission Ops Readiness Plan	MOR-6mos.	3/30/05	MOR+1 mo.	11/15/05	GS	492-MOC-011	J. Nagy	
Training & Certification Plan	MOR+2 mos.	9/30/05	ORR-8 mos.	2/28/06	Internal	492-MOC-012	J. Nagy	
Sustaining Engineering Plan	MOR+8mos.	6/15/06	ORR-2 mos.	10/15/06	Internal	492-MOC-013	J. DeGumbia	
Flight Ops Manual	MOR+2 mos.	12/15/05	ORR-1 mo.	11/15/06	Internal	492-MOC-014	J. Nagy	
MOC Transition Plan			L+8 mos.	10/31/07	GS	492-MOC-015	D. Aldridge	Contract handover to SSMO
Ops Agreements			ORR-2 mos.	10/15/06	GS	492-MOC-xxx		As Needed

MOC Staffing Profile



MOC Schedule

ID	Task Name	Duration	Start	Finish
1	**Project Milestones**	**996 days**	**Thu 5/8/03**	**Wed 2/28/07**
9	**Ground System Milestones**	**849 days**	**Tue 7/22/03**	**Thu 10/19/06**
15	**MOC Development**	**858 days**	**Tue 4/1/03**	**Thu 7/13/06**
16	Ops Concept Document	65 days	Tue 4/1/03	Mon 6/30/03
17	MOC Development Plan	35 days	Mon 7/7/03	Fri 8/22/03
18	MOC Func. & Perf. Requirements	76 days	Fri 8/1/03	Fri 11/14/03
19	Preliminary System Design	99 days	Tue 7/15/03	Fri 11/28/03
20	Final System Design	150 days	Thu 12/4/03	Wed 6/30/04
21	**ICDs**	**195 days**	**Mon 8/4/03**	**Fri 4/30/04**
22	MOC - GSSC/IOCs ICD	68 days	Mon 8/4/03	Wed 11/5/03
23	FDF - MOC ICD	83 days	Mon 12/1/03	Wed 3/24/04
24	MOC - Backup Grnd Stn ICD	87 days	Thu 1/1/04	Fri 4/30/04
25	CM Plan	131 days	Mon 12/1/03	Mon 5/31/04
26	Test Plan	45 days	Fri 5/14/04	Thu 7/15/04
27	**Release 1**	**164 days**	**Tue 6/1/04**	**Fri 1/14/05**
28	Design / Code / Unit Test	96 days	Tue 6/1/04	Tue 10/12/04
29	Integration	21 days	Mon 9/27/04	Mon 10/25/04
30	System Test	65 days	Wed 10/13/04	Tue 1/11/05
31	R1 Delivery	1 day	Fri 1/14/05	Fri 1/14/05
32	**Release 2**	**140 days**	**Mon 1/3/05**	**Fri 7/15/05**
33	Design / Code / Unit Test	82 days	Mon 1/3/05	Tue 4/26/05
34	Integration	22 days	Mon 4/4/05	Tue 5/3/05
35	System Test	55 days	Thu 4/28/05	Wed 7/13/05
36	R2 Delivery	1 day	Fri 7/15/05	Fri 7/15/05
37	**Release 3**	**142 days**	**Fri 7/1/05**	**Mon 1/16/06**
38	Design / Code / Unit Test	91 days	Fri 7/1/05	Fri 11/4/05
39	Integration	22 days	Mon 10/24/05	Tue 11/22/05
40	System Test	50 days	Mon 11/7/05	Fri 1/13/06
41	R3 Delivery	1 day	Mon 1/16/06	Mon 1/16/06
42	**Release 4**	**130 days**	**Fri 1/13/06**	**Thu 7/13/06**
43	Design / Code /Unit Test	55 days	Fri 1/13/06	Thu 3/30/06
44	Integration	22 days	Fri 3/31/06	Mon 5/1/06
45	System Test	50 days	Mon 5/1/06	Fri 7/7/06
46	R4 Delivery	1 day	Thu 7/13/06	Thu 7/13/06
47	**Ground Readiness Tests**	**325 days**	**Tue 2/15/05**	**Mon 5/15/06**
55	**End-to-End Tests**	**258 days**	**Wed 2/8/06**	**Thu 2/1/07**
62	**Operations Prep**	**555 days**	**Mon 8/2/04**	**Fri 9/15/06**
63	Mission Ops Readiness Plan	65 days	Mon 8/2/04	Fri 10/29/04
64	MOC & Ground System Testing	478 days	Wed 9/1/04	Fri 6/30/06
65	Ops Product Dev & Validation	348 days	Fri 4/1/05	Tue 8/1/06
66	Mission Simulations & Rehearsals	185 days	Mon 1/2/06	Fri 9/15/06



Open Items

- ***Finalizing interface definitions – external dependencies***
  - *Resolve mission planning flow/products*
  - *Resolve file transfer mechanism with GSSC, IOCs (MOC selected FastCopy)*
- ***Restricted IONet – definition of rules***
  - *Connection details need to be clarified, impacting MOC network design*
- ***Firewall Redundancy – investigating technical solutions for hot backup***
- ***Backup MOC***
  - *Currently no documented Project Requirements, CCR to GSRD planned (also requires mod to MOC contract); trade study initiated*

Open Trade Study – Contingency MOC

- ***Project has expressed a need for a contingency MOC***
  - *Contingency MOC would maintain mission capabilities until the primary MOC is restored*
- ***Perform trade study to assess functionality and location***
- ***Functionality***
  - *Clone of Primary MOC hardware and software*
    - *Continuation of science with little or no interruption*
    - *Maintain observatory trending data history*
    - *Increased cost for hardware, software, & overhead to maintain*

  OR

  - *Reduced set of MOC hardware and software*
    - *Basic mission health and safety needs*
    - *Trending data restored after failover to contingency MOC*
    - *Reduced cost*

Open Trade Study – Contingency MOC (cont.)

- ***Location***
  - *At GSFC (different building)*
    - *Network infrastructure in place*
    - *Meets security requirements*
    - *Does not protect against center-wide outage*

  OR

  - *Off-site (close proximity to GSFC)*
    - *Increased cost for network and security upgrades*
    - *Protects against center-wide outage*
- ***Goldbelt Orca/Omitron tasked to provide cost estimates to implement each option***

Summary

- ***MOC Ops Concept, Requirements, Design were presented at CDR maturity (July 21, 2004)***
- ***MOC development, test & CM approach has been defined***
- ***Identified open items, issues and external dependencies***

Feedback from this review will be incorporated into the MOC development plans/design.

THE GLAST MOC IS READY TO PROCEED WITH IMPLEMENTATION

Backup Material

Design Trade Studies *(1 of 2)*

Area	*Candidates*	*Selection*	*Reason*
Platform	• Intel X86 • SPARC	Intel X86	*Best value on a price per performance basis.* Reference: http://vegan.net/tony/SPARCvx86.pdf
Operating System	• Sun Solaris x86 • Red Hat Linux Enterprise	Red Hat Linux Enterprise	*Better web, file system, and compilation performance.* Ref.: http://www.osnews.com/story.php?news_id=4867
Architecture	• Message Based (GMSEC) • Hybrid (GMSEC/File Based) • File Based (Legacy Swift)	File Based	*Well known technology, used in the Swift MOC* *Reference:* *GMSEC Evaluation Status Report*
Trending System	• ITPS • TAPS • DTAS	DTAS	*Performance, configuration, cost, future support.* *Reference:* *Trade Study for the GLAST Trending System*
Paging System	• SERS • ANSR/CAT • Komodo • FASAT	FASAT	*2-way paging, web interface, cost, support, next generation SERS* *Reference:* *GLAST MOC Paging and Event Monitoring*

Design Trade Studies *(2 of 2)*

Area	*Candidates*	*Selection*	*Reason*
Flight Dynamics	• Free Flyer • Satellite Tool Kit	Satellite Tool Kit	*Better derivation of attitude, allows for rocking sky survey mode, built in yaw steering capability* *Reference:* *GLAST MOC Flight Dynamics System Trade-Off Study*
Anomaly Tracking	• TrackStudio • TrackGear	TrackGear	*Intuitive UI, state can be reset, automatic date/time update.* *Reference:* *Anomaly Reporting System Evaluation Document*
Event Archiving	• GMSEC Event Archiver • Syslog • Syslog-ng	Syslog-ng	*Reliability, cost, performance, advanced message filtering.* *Reference:* *GLAST Event Logging Architecture Trade Study Document* *Event Logging Evaluation Status Report*
Event Analysis	• GMSEC GREAT • HST CCS Event Viewer • Custom Event Analyzer	Custom Event Analyzer	*Reuse of HST CCS server, will use Java Swing, view & filter real time events & post processing events.* *Reference:* *GLAST Event Logging Architecture Trade Study Document* *Event Logging Evaluation Status Report*
File Transfer Utilities	• DTS • FASTCopy	FASTCopy	*Most secure, easy to install, maintain & troubleshoot* *Reference:* *GLAST MOC Secure File Transfer Product Selection*

Integrated Test & Operations System (ITOS) Overview

Introduction

- **What is ITOS?**
  - A low-cost, highly configurable control and monitoring system
- **What are its current applications?**
  - Satellite development, test, & operations
  - Science instrument development, test, & operations
  - Ground station equipment monitoring & control
- **Who is using ITOS?**
  - SAMPEX, TRACE, FAST, SWAS, WIRE, Triana, Spartan 201, Spartan 251, Spartan 401, Spartan 402, HESSI, Swift, ULDB, PiVot GPS, CIRS, Mars Pathfinder

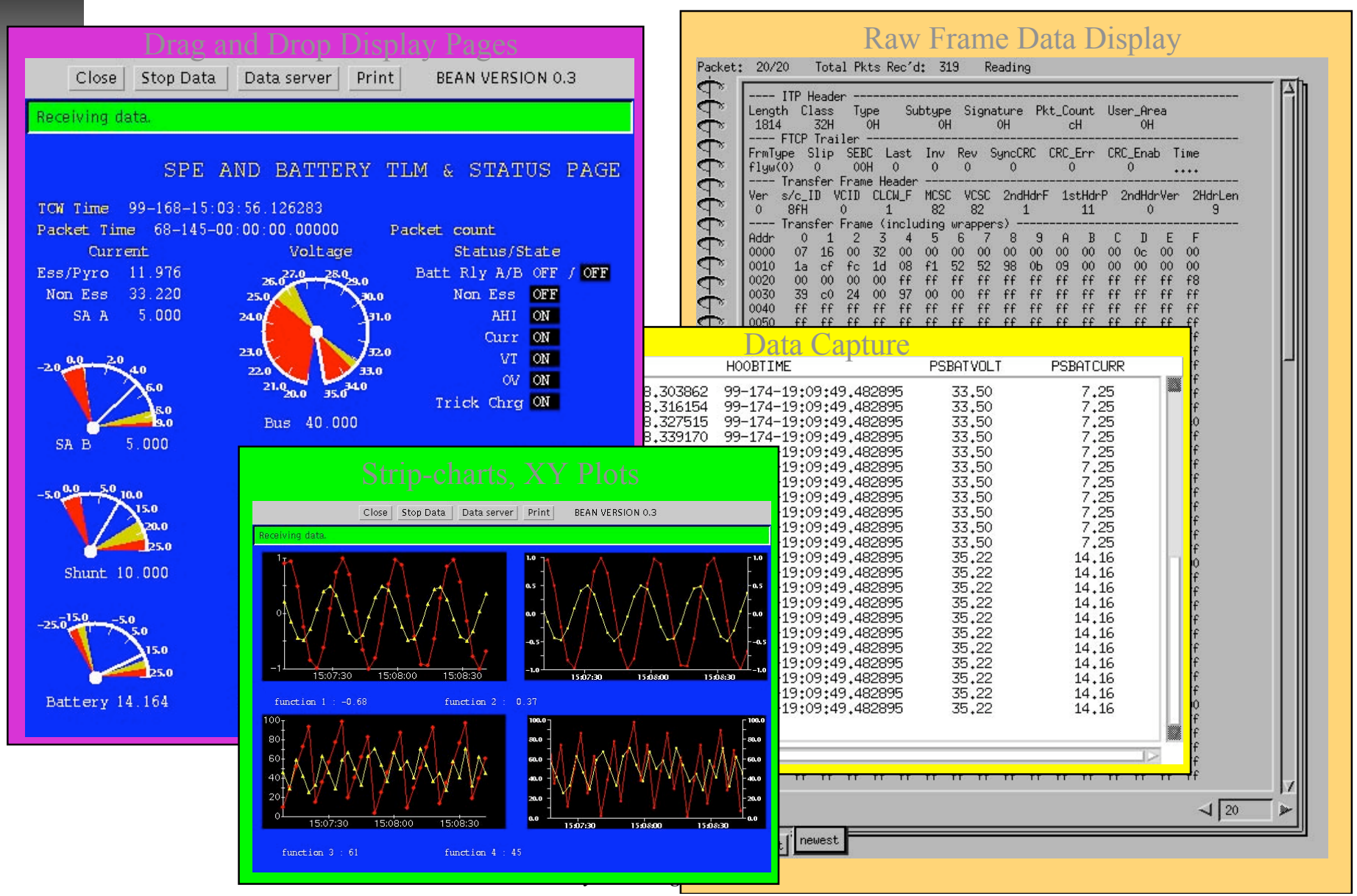
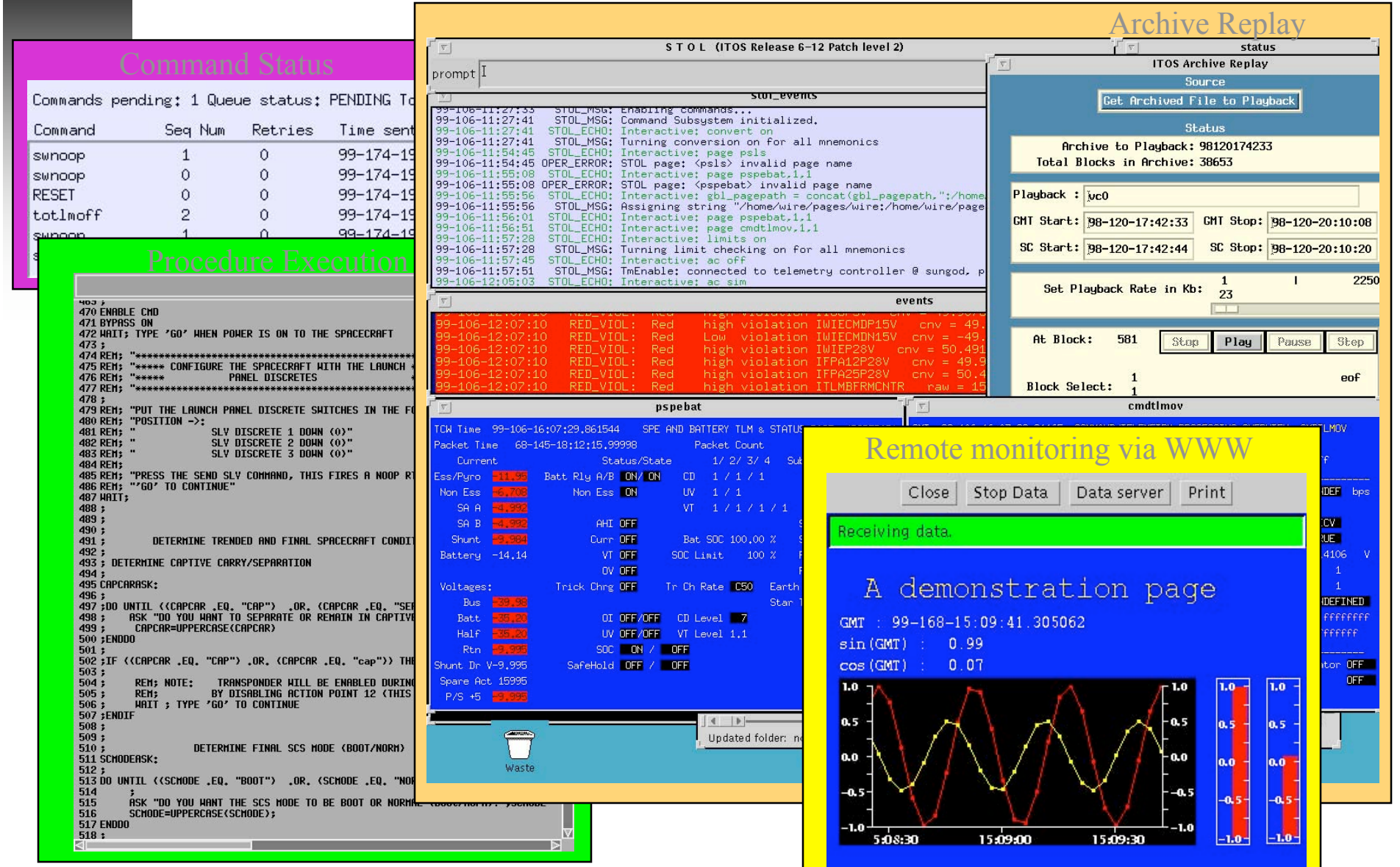
Features and Capabilities

- ***No software licensing cost***
- ***Portable - fully functional on all supported platforms***
  - *PC (FreeBSD, Linux, or Solaris)*
  - *Workstation*
  - *Laptop*
- ***Distributed - can utilize several inexpensive computers for higher performance***
- ***Provides infrastructure required for lights-out operations.***
- ***Easily interfaces to add-on products such as Altair, Apprentice, Genie, and LabView.***
- ***Database driven - ITOS software need not be customized from mission to mission***
- ***No custom front-end required***
- ***Migrates from development labs to operations***
  - *Board/box level*
  - *Subsystem level*
  - *Integration and test*
  - *Mission operations*
- ***Easy interfaces have made ITOS an ideal test bed for integration of new technology***
  - *LabView, Matlab, PV-Wave, VirtualSat, Apprentice, SOTG*
  - *SERS, Genie/GenSAA, SMEX DPS, DTAS*
- ***Supports science instrument development and operations***
  - *Provides data to existing instrument support equipment*
  - *Serves as a base for developing new instrument support equipment*
- ***Handles many data formats including CCSDS and TDM***
- ***Laptop configuration will be used by shuttle astronauts to check-out Spartan free-flyers prior to deployment***

Features and Capabilities

- ***Ingests CCSDS telemetry transfer frame data and reassembles telemetry source packets***
- ***Database driven decommutation of telemetric data***
- ***Real-time data conversion and limit checking of telemetric data***
- ***Distributes telemetry data to users via TCP/IP network***
- ***Provides real-time & off-line data analysis tools***
  - *Packet dumps, sequential prints, XY plotting, strip charts, playback*
- ***Archives processed data for long-term storage***
- ***STOL language***
  - *S/C and ground system control*
  - *Procedure control with logic and arithmetic capability*
  - *TCP/IP, serial, and IEEE-488 external communication*
- ***Time-tagged event messages with audible alarm for critical events***
- ***Image load generator/editor***
- ***Remote display of real-time data and events via web browser using Java (can monitor S/C from home or office)***
- ***Monitors states and initiates actions***
- ***Database driven spacecraft command formatting***
- ***CCSDS COP-1 S/C command and verification capability***
- ***Image load, dump, and compare***
- ***Real-time display of telemetry data with snapshot capability***
- ***Remote control of IEEE-488 and RS-232 instrumentation***
- ***C language and network-based interface to operational database***
- ***WWW access to real-time telemetry***
- ***Software based on X windows, Motif, and Java***
- ***Efficient and portable***
- ***Integrated commercial plotting package***

ITOS Capabilities



ITOS Capabilities